NUMERICAL MODELLING OF CORRELATIONS

O.V.UTYUZH AND G.WILK

The Andrzej Sołtan Institute for Nuclear Studies; Hoża 69; 00-689 Warsaw, Poland
E-mail: utyuzh@fuw.edu.pl and wilk@fuw.edu.pl

Z.WŁODARCZYK

Institute of Physics, Świętokrzyska Academy; Konopnickiej 15; 25-405 Kielce, Poland
E-mail: wlod@pu.kielce.pl

We demonstrate algorithm for numerical modelling of Bose-Einstein correlations (BEC) formulated on quantum statistical level for a single event and exploring the property that identical particles subjected to Bose statistics do bunch themselves in a maximal possible way in the same cells in phase-space.

Bose-Einstein correlations (BEC) between identical bosons are supposed to provide information on space-time development of multiparticle production processes [1]. The usual Monte Carlo event generators modelling such processes [2], because their probabilistic structure, excludes *a priori* the genuine BEC, which are of purely quantum statistical origin. One can only *model* BEC by (i) suitably changing output of these generators [3,4,5] or by (ii) building generator, which properly incorporates the bosonic character of produced particles [6]. In both cases the goal is to reproduce the experimental two-particle correlation function $C_2(Q=|p_i-p_j|)=N_2(p_i,p_j)/N_1(p_i)N_1(p_j)$. In (i) this is achieved by suitable bunching of the finally produced identical particles in phase-space performed using special weights constructed from the output of the event generator. In (ii) the particles are already being produced in properly bunched way by means of special generator constructed using specific statistical model (providing Bose-Einstein or geometrical distribution of particles in each bunch which is identified with a single emitting cell in phase space [6]). Whereas (i) can be applied only for all events and is (via weights) sensitive to the space-time structure of the production process provided by event generator, the (ii) applies already on a single event level but its generator bears no a priori information on the space-time structure of the production process, it uses instead nonstatistical character of fluctuations it produces.

We propose generalization of the second approach to make it applicable also to other generators[a]. To better understand our reasoning let us remind

[a] Cf. [7] for more details, especially in what concerns the hadronization model CAS used in

that classical weight method [4] amounts to multiplying each event by special weight, i.e., event is counted many times if it already possesses, by shear chance, traces of desired bunching. In terms of philosophy of [6], which we shall follow, it could be seen as selecting events already possesing (to some degree, at least) a more bosonic character than other events (i.e., in which particles are already bunched in way resembling that of [6]). What we propose is similar approach but performed already on a single event level. Namely we propose to search for the bosonic configurations of particles existing already in each event because of the internal nonstatistical fluctuations provided by event generator. Namely, there are groups of particles resembling those obtained in [6], modulo only the fact that they usually have different charges allocated to them whereas particles in [6] are of the same charge. We propose therefore to endow such bunches of particles with the same charge to an extent limited only by the overall charge conservation. This means that in cases where charge allocation has been already provided by event generator we shall neglect it and perform new charge allocation keeping, however, the total number of particles of each charge the same as given by this generator. Notice that we do it for each single event, keeping intact both the original energy-momentum pattern provided by event generator (i.e., conserve the energy-momentum) and all inclusive single particle distributions. Leaving those interested in more details to [7] we shall only say that to get desired result it is enough to select one of the produced particles, allocate to it some charge, and then allocate (in some prescribe way) the same charge to as many particles located near it in the phase space as possible. In this way one forms a cell in phase-space, which is occupied by particles of the same charge only. This process should then be repeated until all particles are used and it should be such that one gets geometrical (Bose-Einstein) distribution of particles in a given cell. This procedure changes the charge flow pattern provided by event generator[b] retaining, however, both the initial charge of the system and its total multiplicity distribution. The procedure of formation of such cells is controlled by probability P that given neighbor of the initially selected particle should be counted as another member of the newly created emmiting cell in phase space[c].

Referring to [7] for more details we shall illustrate in Figs. 1a and 1b

calculating results in Fig. 1.

[b]It amounts to allowing formation of multi-like-charged object on intermediate steps of hadronization process. Therefore this method works only when such possibility exists in a given generator.

[c]It is important to realize that, because we do not restrict *a priori* the number of particles which can be put in a given cell, we are automatically getting BEC of *all orders* (even if we use only two particle checking procedure at a given step in our algorithm). It means that $C_2(Q=0)$ calculated in such environment of the possible multiparticle BEC can exceed 2.

our attempts to describe (separately) e^+e^- data by DELPHI on BEC [8] and intermittency [9] using the so called CAS model [10] (see also [7]) whereas Figs. 1c and 1d show the respective intermittency and BEC obtained when using parameters from the fits above. The results, although not totally satisfactory, are encouraging given the simplicity of CAS model used. Application of our method with other, more sophisticated event generators should answer the question of its final applicability.

Acknowledgments

Authors OU and GW would like to thank Wu Yuangfang and all Organizers of XXXI-th ISMD for their kind hospitality and GW acknowledges financial support received. The partial support of Polish Committee for Scientific Research (grants 2P03B 011 18, 5P03B 091 21 and 621/E-78/SPUB/CERN/P-03/DZ4/99) is acknowledged.

References

1. R.M.Weiner, *Phys. Rep.* **327**, 249 (2000); U.A.Wiedemann and U.Heinz, *Phys. Rep.* **319**, 145 (1999); T.Csörgő, in *Particle Production Spanning MeV and TeV Energies*, eds. W.Kittel et al., NATO Science Series C, Vol. 554, Kluwer Acad. Pub. (2000), p. 203 (see also: hep-ph/0001233).
2. Cf., K.J.Escola, *On predictions of the first results from RHIC*, hep-ph/0104058, to be published in Proc. of QM2001, *Nucl. Phys.* **A** (2001).
3. L.Lönnblad and T.Sjöstrand, *Eur. Phys. J.* **C2** (1998) 165.
4. A.Białas and A.Krzywicki, *Phys. Lett.* **B354**, (1995) 134; T.Wibig, *Phys. Rev.* **D53** (1996) 3586; K.Fiałkowski and R.Wit, *Eur. Phys. J.* **C2**, 691 (1998) 691; B.Andersson and M.Ringnér, *Nucl. Phys.* **B513** (1998) 627.
5. J.P.Sullivan et al., *Phys. Rev. Lett.* **70**, (1993) 3000; K.Geiger, J.Ellis, U.Heinz and U.A.Wiedemann, *Phys. Rev.* **D61** (2000) 054002.
6. T.Osada, M.Maruyama and F.Takagi, *Phys. Rev.* **D59** (1999) 014024 (cf. also M.Biyajima, N.Suzuki, G.Wilk and Z.Włodarczyk, *Phys. Lett.* **B386** (1996)) 297).
7. O.V.Utyuzh, G.Wilk and Z.Włodarczyk, in the Proc. of the XXX ISMD, Tihany, Hungary, 9-13 October 2000, Eds. T.Csörgő et al., World Scientific 2001, p. 373 (hep-ph/0101161, cf. also hep-ph/0102275).
8. P.Abreu et al. (DELPHI Collab.), *Phys. Lett.* **B286** (1992) 201.
9. P.Abreu et al. (DELPHI Collab.), *Phys. Lett.* **B247** (1990) 137.
10. O.V.Utyuzh, G.Wilk and Z.Włodarczyk, *Phys. Rev.* **D61** (2000) 034007 and *Czech J. Phys.* **50/S2** (2000) 132 (hep-ph/9910355).

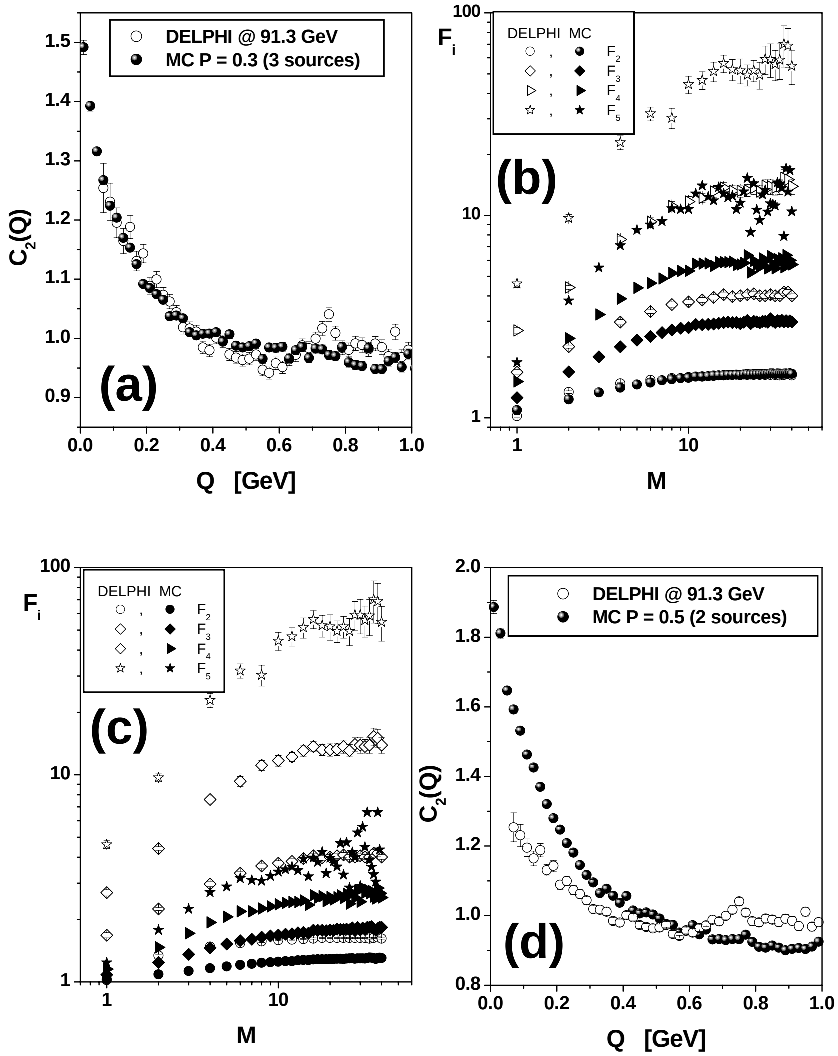

Figure 1. The examples of best fits to data on e^+e^- annihilation by DELPHI on BEC [8] in (a) and, separately, on factorial moments [9] F_i in (b) (M is number of bins) using simple cascade hadronization model CAS (cf. [7,10] for details). In (c) are shown factorial moments for parameters used in (a) (when fitting BEC) whereas in (d) BEC for parameters used in (b) (when fitting factorial moments). Notice that left panels ((a) and (c)) are obtained for 3 sources whereas right panels ((b) and (d)) for 2 sources. To fit F_5 one needs $P = 0.75$ and two sources, but in this case the calculated F_2 overshoots data by ca 50%.